TENSILE TEST OF ALUMINIUM AT HIGH TEMPERATURE

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

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By

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TENSILE TEST OF ALUMINIUM AT HIGH TEMPERATURE

A project under the guidance of

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CERTIFICATE

This is to certify that the thesis entitled "**TENSILE TEST OF ALUMINIUM AT HIGH TEMPERATURE**" submitted by Mr.Aniruddha Meena in partial fulfillment of the requirements for the award of Bachelor of technology Degree in Mechanical Engineering at the National Institute of Technology Rourkela (Deemed University) is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University / Institute for the award of any Degree or Diploma.

Date: ……………………

……………………………………………..

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ANIRUDDHA MEENA

CONTENTS

ABSTRACT:

The necking of specimen is specifically related to the decrease in cross section when specimen is subjected to tensile strength greater than ultimate tensile strength (UTS). The strain distribution no longer hold uniform along the gauge length. As the tensile load is applied, due to which length of specimen increases but there is decrease in cross section.

The present work laid stress on determining the tensile properties from stress strain curve by tensile testing of aluminium (specimen) at different range of high temperature The tensile testing is carried out on INSTRON static series 600 KN. The specimens were tested at different range of high temperature (Room Temperature -325 degree Celsius). True Stress and strain is calculated using the engineering equation. Using the values of true stress and true strain the true stress strain curve was plotted. The polynomial equation is obtained from each specimen curve. The graph is plotted between temperature and ultimate tensile strength (UTS) which indicates that the ultimate tensile strength decreases with the increase in temperature.

1. LITERATURE REVIEW

From the literature review , the work on "High temperature tensile behaviour of a Cu–1.5 wt.% Ti alloy" By **S.** Nagarjuna and M. Srinivas was done at Defence Metallurgical Research Laboratory at Defence Research and Development Org.The high temperature tensile properties of a Cu–1.5 wt.% Ti alloy have been investigated in the temperature range of 100–550 °C. Substantial increase in yield and tensile strengths of solution treated alloy is observed with increasing temperature, with a peak at 450 °C and decrease in strength beyond this temperature. Cu–Ti alloys have been developed with the aim of substituting them for the toxic and expensive Cu–Be alloys. It reports the results obtained on high temperature tensile properties of a Cu–1.5 wt. % Ti alloy in solution treated (ST) and peak aged (PA) conditions.

In the paper "Tensile properties of Ti_3SiC_2 in the 25–1300°C temperature range" By M. Radovic M. W. BarsoumT. El-Raghy J. Seidensticker and S. Wiederhorn .The ternary carbide Ti_3SiC_2 exhibits a unique combination of properties that have been studied. It report on the functional dependence of the tensile response of fine-grained (3–5 μm) Ti_3SiC_2 samples on strain rates in the 25–1300°C temperature range. High temperature mechanical properties; Stress–strain relationship measurements; Plastic; Creep; It reported on the properties of fine- and coarse-grained, predominately single-phase Ti_3SiC_2 samples in compression and flexure. In both cases, a brittle-to-plastic transition occurs at ≈1200°C, at which point large plastic deformation levels (strains >20%) are obtained prior to failure.

In paper High-temperature mechanical properties of aluminium alloys reinforced with boron carbide particles J. O˜noroa,∗, M.D. Salvadorb, L.E.G. Camboneroc. The tensile properties and fracture analysis of these materials were investigated at room temperature and at high temperature to determine their ultimate strength and strain to failure. The fracture surface was analysed by scanning electron microscopy.

However, very little work is devoted to tensile testing of aluminium at high temperature. The present work focuses on determining the tensile properties of aluminium when subjected to necking at high temperature.

2. INTRODUCTION

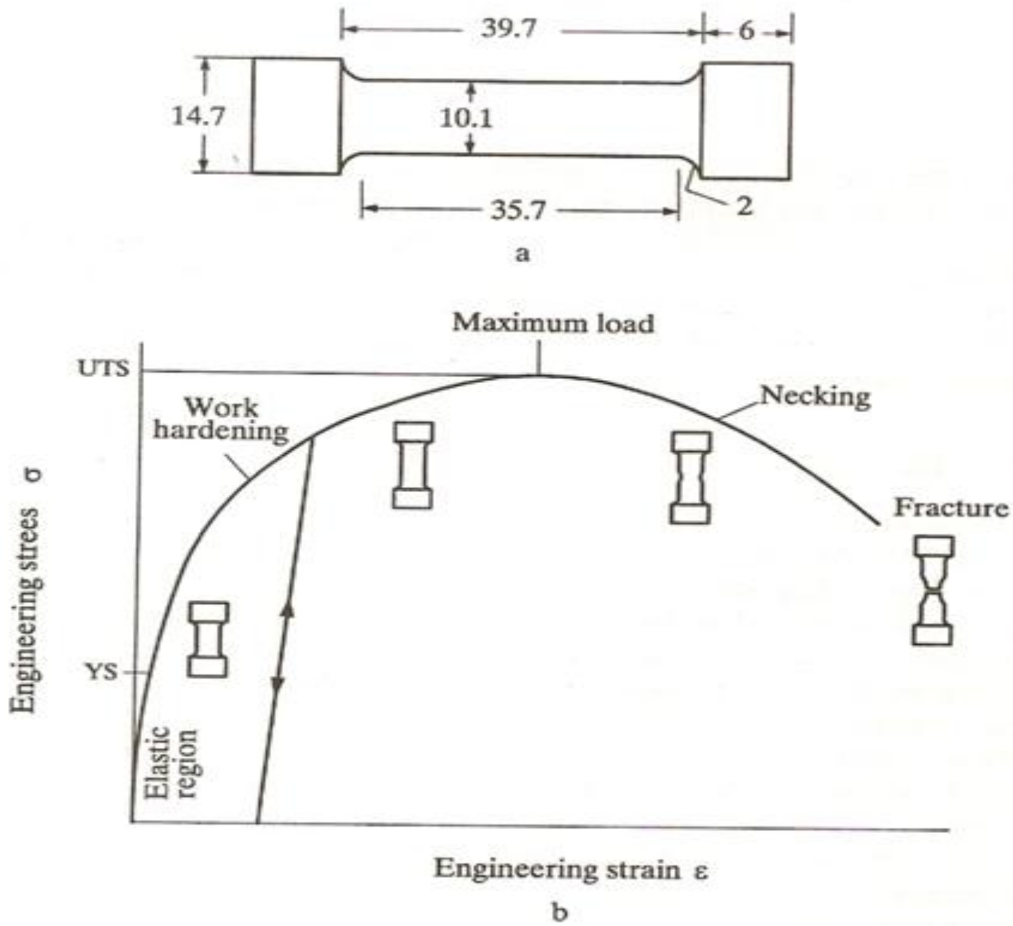
The tensile properties of Al, Cu, stainless steel and its alloy examined in the high temperature the need for materials with useful strength above 1600k has stimulates the interest in refractory alloys .Cast aluminium alloys have found wide application to manufacture lighted-weight components of complex shape in automotive and aerospace industries. To improve the strength and ductility of cast aluminium alloys, it is necessary to study their fracture properties by conducting a series of tests.

The tensile properties of Al are strength ductility creep. the temperature range of 37 C to 350 C That temperature is maintain inside furnace . tensile testing of aluminium with high temperature in INSTRON static series . the aluminium is tested with different temperature range we have taken the range . 37 c (room temp.),90,130,170,210,250,290,325 C

THE TENSILE TEST

The engineering stress-strain curve Specimens used in a tensile test are prepared according to standard specifications. The test pieces can be cylindrical or flat. Figure S.la shows the standard dimension of a typical cylindrical specimen. It is gripped at the two ends and pulled apart in a machine by the application of a load. The stress-strain curve obtained from the tensile test of a typical ductile metal is shown in Fig. On the y-axis, the engineering stress, defined as the load P divided by the original cross-sectional area Ao of the test piece, is plotted. The engineering strain E, defined as the change in length 1L divided by the initial gauge length La is plotted on the x-axis. The % elongation is obtained by multiplying the engineering strain by 100.

The stress-strain curve starts with elastic deformation. The stress is proportional to strain in this region, as given by Hooke's law. At the end of the elastic region, plastic deformation starts. The engineering stress corresponding to this transition is known as the yield strength (YS), an important design



The tensile test: (a) a standard cylindrical test specimen (dimensions in mm), and (b) the engineering stress-strain curve.

parameter. Many metals exhibit a continuous transition from the elastic region to the plastic region. In such cases, the precise determination of the yield strength is difficult. A parameter called proof strength (or offset yield strength!

that corresponds to a specified permanent set is used. After loading up to the proof stress level and unloading, the specimen shows a permanent elongation of 0.1 or 0.2%.

The stress-strain curve has a positive slope in the plastic region, indicating that the stress required to cause further deformation increases with increasing strain, a phenomenon known as work hardening or strain hardening. If the load is removed when the specimen is in the plastic region, it retraces a straight line path parallel to the initial line and reaches zero stress at a finite value of permanent elongation, see

Above fig. Thus, the elastic part of the deformation is recovered. On reloading, plastic deformation starts only on reaching the stress level prior to unloading.

The engineering stress reaches a maximum and then decreases. The maximum value is known as the ultimate tensile strength (UTS) or simply the tensile strength Up to the UTS, the strain is uniformly distributed along the gauge length .Beyond UTS, somewhere near the middle of the specimen, a localized cease in cross-section known as necking develops. Once the neck forms, further deformation is concentrated in the neck. The strain is no longer uniform along the gauge length. The cross-sectional area of the neck continuously decreases, as the % elongation increases. Voids nucleate in the necked region at the interface of hard second-phase particles in the material. These voids grow and coalesce, as the strain increases. The true cross-section bearing the a C becomes very small, as compared to the apparent cross-section, due to the growth of these internal voids. At this stage, the specimen may fractural shows that ductility measured in terms of the true strain at fracture ec below for definition of true strain) decreases with increasing concentration

PROPERTIES

Aluminium has a flexible durable. Lightweight malleable metal by means of appearance range from silvery to dull grey, depending on the surface roughness. Al is nonmagnetic and non sparking. It may too unsolvable in alcohol, though it may be soluble in the water forms. The yield strength of pure Al is 6to12MPa, while aluminium alloys has yield strengths from 201 MPa to 600 MPa. Aluminium has about one third the density and stiffness of the steel. It is ductile, and simply machined, cast, drawn and extruded.

Corrosion resistance may be brilliant due to a slim surface layer of aluminium oxide when the metal is uncovered to air, effectively prevent additional oxidation. The strongest Al alloys are not as much of corrosion resistant due to galvanic reaction with alloyed copper. It corrosion resistance has also frequently greatly reduced when many aqueous salts are in attendance however, mainly in the presence of unlike metals.

Aluminium atom is arranged in a face centre cubic (fcc) structure. Al is stacking fault energy of approximately 200 mJ/m².

Aluminium is one of the small number of metals that keep full silvery reflectance in thinly powdered form making it significant constituent of silver paints. Aluminium is a superior thermal and electrical conductor, by weight improved than copper. Aluminium is able of being a superconductor, among a superconducting critical temperature of 1.2 kelvin

- **Strength Weight Ratio**

Aluminium has density approximately one third that of steel and is utilize benefit in application where high strength and low weight are required. That is include vehicle where low mass consequences in greater load capability and reduced fuel utilization.

- **Corrosion Resistance of Al**

  When the surface of aluminium metal has uncovered in to air. The protective oxide coating form almost instantaneously. This oxide film has corrosion resistant Aluminium is good corrosion resistance

- **Electrical and Thermal Conductivity of Al** Aluminium is an brilliant conductor of both heat and electricity. The huge benefit of Al is that by weight, the conductivity of Al is twice that of copper. That means the Al is at present the most normally used material in large power transmission lines.

Light and Heat Reflectivity of Al

Aluminium is high quality reflector of both able to be seen light and heat creation it perfect material for light fittings. thermal liberate blanket and architectural insulation.

- **Toxicity of Aluminium**

Aluminium is not only nontoxic but also does not discharge any spoil products with which it is in get in touch with. This makes Al appropriate for used in covering for responsive products such as food .where Al foil is used.

Recyclability of Al

The recyclability of has unparalleled. When recycled there no degradation in properties when recycled Al can compared to virgin aluminium. Furthermore recycling of Al only require approximately 5 percent of the input energy necessary to create virgin Al metal.

Aluminium Production

Aluminiumis extracted the principal ore, bauxite. Significant bauxite deposits have found in Australia. the Caribbean. China and South America. Open cut techniques has normally used to mine the bauxite.

Smelting of Aluminium

The removal of aluminium from alumina has achieve using an electrolytic method. A cell or vessel has used that consists of a carbon lined steel shell. That shell forms a cathode. A consumable carbon anode has suspended in liquid cryolite held inside the pot at 950°C. Alumina is dissolve in the cryolite by transitory low voltages at high amperages through pot. That consequences in pure Al being deposit at the cathode.

Environmental Considerations

The aluminium industry has very conscious of the environmental impact of it is activities. The mining and smelting of Al benefit the removal of red sludge can have a main environmental impact

Properties of Al

Aluminium is unique and unbeatable combination of properties this making its into the versatile. High usable and attractive construction material.

Weight
Al is the light material compare to other material like steel density is 2.700 kg/m3

Strength

Aluminium has strong with the tensile strength 70 to 700 MPa depend on the alloy and manufacture processing .

Elasticity

The Young's modulus of Al has third time of steel (E = 70,000 MPa). That mean the moment of inertia has to three times as great for an Al .

Formability

Aluminium has the good formability .characteristic that may be used to the full in extrusion. Aluminium may be also cast drawn and milled.

Machining

Aluminium is very simple to machine. Ordinary machining equipmentmay be used such as saws and drills. Al has also suitable for forming both hot and cold process .

Joining

Aluminium may be joining applying all the normal methods available. As the welding. Soldering. Adhesive bonding and riveting.

Corrosionresistance

A thin layer of oxide has formed and contact with air.which is provided the good protection against the corrosion in the corrosive environmental . its layer may be further strength by surface treatment such the powder coating.

Conductivity

If the thermal and electrical conductivitie has good to compared with copper. Further Al conductor is only 1/2 weight of an equivalent cu conductor.

Linearexpansion

Aluminium is relatively high coefficient linear expansion compared to other metals. This shall be taking into account of the design stage of the compensate for difference in the expansion.

Non-toxic

Aluminium has not poisonous there for it is highly suitable for the preparing and storage of the meal

Reflectivity

Aluminium hase the best reflector of the light and heat.so its reflectivity is very high.

CHEMICAL PROPERTIES Properties -

Atomic number	13
Atomic mass	26.98154 g.mol $^{-1}$
Electronegativity according to Pauling	1.5
Density	2.7 g.cm $^{-3}$ at 20 °C
Melting point	660.4 °C
Boiling point	2467 °C
Vanderwaals radius	0.143 nm
Ionic radius	0.05 nm
Isotopes	3
Artificial isotopes	16
Electronic shell	$1s^2 2s^2 2p^6 3s^2 3p^1$
Energy of first ionization	577.4 kJ.mol $^{-1}$
Energy of second ionization	1816.1 kJ.mol $^{-}$
Energy of third ionization	2744.1 kJ.mol $^{-1}$
Standard potential	- 1.67 V
Discovered by	Hans Christian Oersted in 1825

High Temperature Alloys

The properties required in a hing temperature alloy

1. Good oxidation resistance .
2. Adequate creep strength.
3. Microstructure stability, i.e no deterioration of microstructure and properties with time at the service temperature

4. Depending on the application , other properties such as corrosion resistance fatigue strength and impact toughness may be required for example, turbine blades undergo stress reversals and must have sufficient fatigue strength at the operating temperature.
5. The alloy must be capable of easy fabrication and should not undergo

large property changes on heating and cooling. (Jet engine parts repeatedly cool down and heat up, as the engine is shut off and restarted.)

A number of alloys which can serve at high temperatures have alreac:T introduced in earlier sections and chapters. Here, only a short summary ing such alloys as are not discussed up to now) is given.

In low alloy steel, molybdenum and vanadium are the two alloying elements which significantly improve the creep resistance. 0.5%Mo steel for pressure vessels and superheater tubes for use up to 450°C. The service temperature can be increased by about 100°C by the addition of 1-29%Cr. Which improve the resistance to graphitigation.

Stainless steels possess many of the properties required of high temperature alloys. Mansitic stainless steels have adequate creep strength and good corrosion and oxidation resistance up to 650°C. For higher temperatme, the excellent oxidation resistance of ferritic stainless steels such as 430 and 446 can be used. The creep strength and corrosion resistance of austenitic stainlesteels are the best. They are used up to 900°C in applications such as furnace linings and exhaust systems

THE LIGHT ALLOYS

Introduction The light metals are Be, Mg, Al and Ti. Their specific gravities and Young's module Yare compared with those of other common metals below:

Metal	Specific gravity	Y. ON m-2
Ti	4.5	106
Be	1.86	289
Mg	1.74	44
Al	2.71	71

Fe	7.86	210
Cu	8.9	124
Pb	11.3	15.7

In the following table, the mass of metal required for the same stiffness of beams of equal length is compared using steel as reference:

Metal	Comparative mass
Steels	1
Ti	0.81
Al	0.59
Mg	0.48
Be	0.20

In addition to weight saving seen in the above table, with a smaller mass, the inertial forces are less in reciprocating parts such as connecting rods and pistons. Also, the elastic buckling of slender columns or wrinkling of thin sheets bearing loads is less of a problem with light metals and their alloys, as they aave a larger volume (and thickness) for the same stiffness.The other desirable properties of the light metals are listed below:

Metals	properties
1 Aluminium	High corrosion resistance High electrical conductivity High thermal conductivity
2 Magnesium	Outstanding machinability
3 Titanium	Outstanding corrosion resistance

The major disadvantage of the light metals is the large energy requirement for production. For aluminium, the energy required is 75,000 kWh per tonne from are to primary metal, which is five times that for steel. The energy requirements for magnesium and titanium are even larger. However, aluminium scrap requires only 5% of the energy required for the production of the primary metal from the ore. So, recycling is an important process.

- **Classification of aluminium alloys** The AAA (Aluminium Association of .,../America) classification for wrought aluminium alloys has been adopted by the International Alloy Development System (lADS) and is now accepted by most countries. The classification is based on a four-digit system.

lxxx	Commercial purity and high purity aluminium
2xxx	AI-Cu alloys
3xxx	AI-Mn ,alloys
4xxx	AI-Si alloys
5xxx	AI-Mg alloys
6xxx	AI-Mg-Si alloys
7xxx	AI-Zn alloys

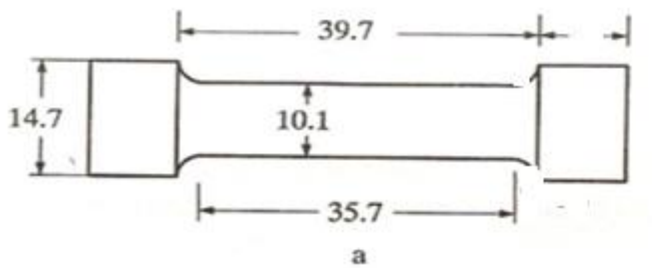
- Non heat-treatable aluminium alloys Starting with aluminium metal, we note that pure aluminium (l350H16 in Table 7.1) is used in the electrical industry. Even though the electrical conductivity of aluminium is only 60% of that of copper, for equal weight, the conductivity is 200% of copper, as aluminium of the same weight has more than three times the volume of copper. After the electrical industry, the largest use for aluminium is in the packaging industry.aluminium is attractive for this purpose, due to its good corrosion resistance high termal conductivity and impenetrability to oxygen.

- **Heat treatable aluminium alloy** the following aluminium alloy can be givin an age hardening treatment In the 2xxx series of Al-Cu alloys CuAl2 and the associated transiton phase from the precipitates, to improve the corrosion resistance ,Al-Cu alloys are sandwiched between two pure aluminium sheets and rolled to produce the composite Alcadications such as furnace linings and exhaust systems

3. EXPERIMENTAL PROCEDURE

SPECIMEN PREPARATION

Before performing the test. Specimen of standard size and shape must be produced from the material to be tested for the result to be comparable. It is strongly advised to manufacture .the specimen size and shape according to standard. We are using the round test bar .Round test bar are used for sheet/plate with thickness. We are show the standard size specimen



Standard specimen

In this specimen size and shape are standard .standard are thread radius gauge length of reduction section and diameter and we have used specimen is not that size it is different nomenclature . first one when we are preparing the specimen we have taken the aluminium rod 1000mm long and diameter is 12mm.then we have cut that rod in 100mm ten part. Each part having the same length 100mm . now we are making the thread in specimen both side 15 mm length by using the thread making die (srew thread).

THREAD DIE- Die is cuts the thread on performing rod. Which has been produced the male thread. the die is shown are top left an older split die with top adjusting a cylinderical blank. Which has usually slight less than. That is required diameter has machined with the tapper at thread end . thus taper allow the die to ease onto the blank before it is cut the sufficient threads to pull itself along .

Figure 3.1 Thread making die

MAKING A SREW THREAD- the thread are three type parallel thread for piping(pf) a tapper thread for piping (pt) and unified thread (unf) . two type term are used for thread . first one is the male thread as the making outer thread and second one is the inner thread . we have making the inner thread .

After making the thread we have doing the turning in the middle 70mm part of specimen . it’s mean 700mm length where we are doing the turning in lathe machine

Figure 3.2 Lathe machine

Because the 70mm middle part making the 6mm diameter for standard size and shape

Turning introduction; turning is one of the main types of machining where material is removed using cutting tool . it's allow rotating parts to be produced using a single edge cutting tool. After completing the turning the finishing of the specimen by using the sand paper .after doing that work we have make a standard size specimen that specimen having the 100mm long and 12mm diameter . both side 15mm having the thread and middle part having the diameter is 6 mm .that is our specimen standard size and shape .

To receive exact result when performing a tensile test. First one we need a perfect prepared tensile specimen this specimen has to meet the standard as well as the mechanical requirement . if the specimen has a bad quality the result of ours test are wrong and not reliable .

Tensile specimens those do not have a perfect edge flank never will give you the high elongation the material is able to do. often you loose 1/8….1/3 of the possible elongation .

Metallographic Specimen Preparation Basics

Metallographic has the study of materials basic and fundamental . Analys of the materials micro structure aid in determine if the material has processes. therefore the critical step for determine the product reliability and for determine why that material material failed. The fundamental and basic steps for exact metallographic specimen preparing include documentation section and cutting mounting, planar grinding, rough polishing, final polishing, etching, microscopic analysis, and hardness testing.
Documentation - Metallographic analysis has the valuable tool. properly documenting the initial specimen condition the proceeding micro structural analysis, metallography provides the powerful quality control an invaluable investigative tool.

Sectioning and Cutting - most metallographic samples need to sectioned to the area of interest and for easier handling. Depending upon the material the sectioning operation may be obtained by abrasive cutting Proper sectioning is required to minimize damage, which may alter the microstructure and produce false metallographic characterization. Proper cutting requires the correct selection of abrasive type, bonding, and size and proper cutting speed, load and coolant.

Mounting - The mounting operation accomplished three important functions first its protect the specimen edge and maintain the integrity to the materials surface features second has the fills voids in porous materials and third one is the improves handling of irregular shaped samples especially for automated specimen preparation.

Planar Grinding - ofcourse grinding has required to planarize a specimen and reduce the damage created by sectioning. The planar grinding step has accomplished by decreasing the abrasive particle size and shape to obtain the surface finishes that is ready to polishing. Care must be taken to avoid being too abrasive in that step and actually creating greater specimen damage than produced during cutting The machine parameters which effect the preparation of metallographic specimens, include grinding/polishing pressure, relative velocity distribution, and the direction of grinding/polishing.

Rough Polishing - the rough polishing step has been use to remove the damage produced during cutting and planar grinding. Exact rough polishing shall be maintain specimen flat. By eliminating the previous damage and maintaining the micro structural integrity of the specimen

Final Polishing – the final polishing has be remove only surface damage. It shall not be use to remove any damage remaining from cutting and planar grinding. If the damage has not complete.the rough polishing should be repeated .

Reference **(** Metallographic Specimen Preparation Basics By Donald C. Zippering, Ph.D. Pace Technologies)

Thus finally we have prepare the specimen of aluminum material

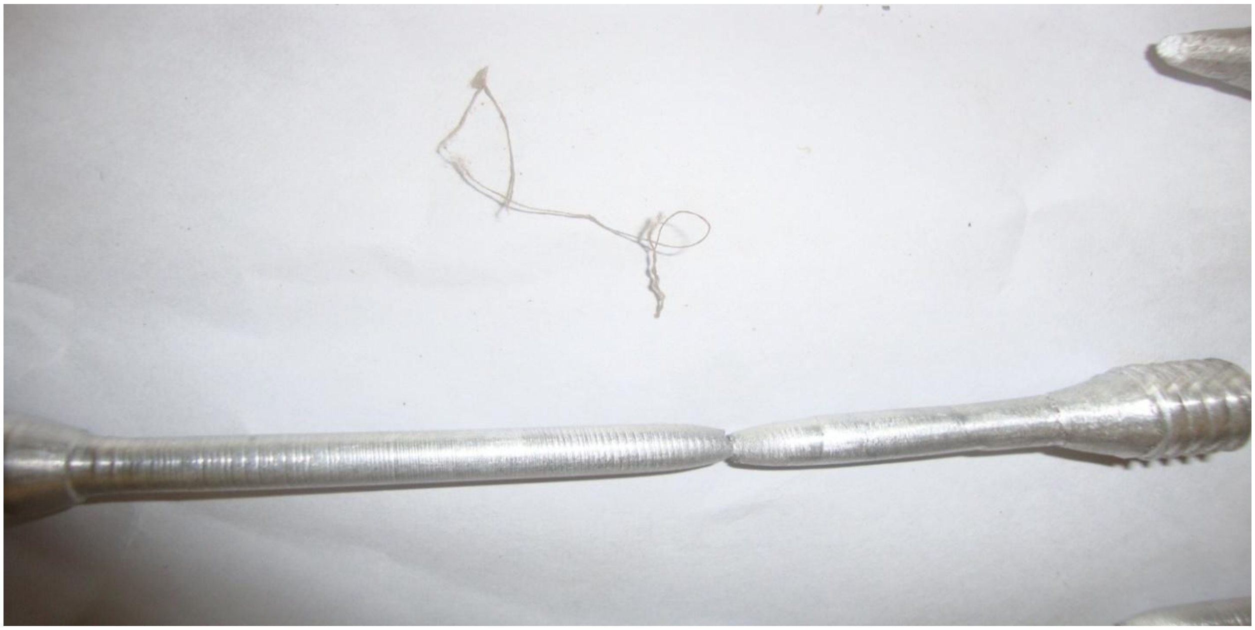


Figure 3.3 Aluminium specimen

After preparing the specimen . the specimen is proper standard size and shape . now we are doing the experiment in INSTRON static series 600KN machine

All aluminium specimen

EXPERIMENT :-

SATEC Series KN Model Universal Testing Machines

This machine is designed for the high capacity tension test compression bending test and shear testing .the main design of the KN Model provides the ultimate in versatility. We are using for tensile test with high temperature

Features

- Single ultra-large test space accommodates an assortment of specimen size grip fixture furnace and extensometry.
- Optional Hydraulic Lifts and Locks allow quick and easy repositioning of the crosshead over the length of the column.
- It is provide the fast test speed and long test stroke provide capability to meet variety of testing requirements.
- Alignment head maintains accurate alignment of the load string over the entire stroke of the actuator.
- Choice of Partner or Bluehill Universal Materials Software provides the ultimate in ease-of-operation and flexibility.
- Optional full capacity hydraulic wedge grips offer fully open-front design making specimen loading efficient and safe for the operator.

Model range

600KN

- 600 kN (135,000 lbf)

When specimen were prepared . aluminium specimen 100mm long and 6mm diameter is testing in INSTRON static series 600KN . these specimen is testing for tensile properties at high temperature (RT,90,130,170,210,250;290,325 C).

Figure 3.4 INSTRON static

Tensile test also known as tension test has probably the most fundamental type of mechanical test you may be perform on material. Tensile test is simple, relatively inexpensive, and fully standardized. By pulling on something you should very quickly determine how the material will react to forces being applied in tension. The material has being pulled. you will find its strength along with how much it would be elongate. Method for determining behavior of materials under axial stretch loading. Data from test have used to determine elastic limit, elongation, modulus of elasticity, proportional limit, reduction in area, tensile strength, yield point, Yield_Strength and other tensile properties.

Strain You would also be able to found out the amount of elongation the specimen undergoes during tensile testing This may be expressed an absolute measurement the change in length or as relative measurement called "strain". Strain itself can be expressed in two different ways engineering strain and true strain . Engineering strain has probably the easiest and the most common expression of strain used. It is the ratio of the change in length to the original length, $e = \frac{L - L_0}{L_0} = \frac{\Delta L}{L_0}$. Whereas the true strain is similar but based on the instantaneous length of the specimen as the test progresses , $\varepsilon = \ln\left(\frac{L_i}{L_0}\right)$, where L_i is the instantaneous length and $L_0$the initial length.

Specimen Shape The specimen's shape has usually defined by the standard specification being utilized, e.g., ASTM E8 Its form is main because you would like to avoid having a break ,fracture inside the area being absorbed. So normal has been developed the state to shape of the specimen to sure the break would be happen in the gage length by reduced the cross sectional area or dia.of the specimen throughout the gage length. it is the produce of increasing stress in the gage length because stress has inversely proportional to the cross sectional area under the load, $\sigma = \frac{\text{Load}}{\text{Area}} = \frac{P}{a}$.

We know the volume(V) is constant always. So we find out the area of each specimen and find out the stress by using the engineering stress formula.

Grip withFace Selection

Face and grip choice has a very important factor. By not choose the right set up. Our specimen can be slide or even fracture inside the gripped area (jaw break). This will be lead to invalid results. The faces shall be cover the entire area to be gripped. You do not like to use serrated facade when testing material that are extremely ductile. from time to time cover the serrated face with masking tape will become softer the bite prevent damage in the specimen.

Specimen Alignment Vertical aligns of the specimen is significant thing to avoid side loading or bending moment created in the specimen. Mounting the specimen in the higher grip assemblage primary then allow it to hang generously will assist to keep alliance for the test.

Figure 3.5 Specimen alignment with extension rod

In Instron machine tension testers or pull testers.have used to find out the tensile strength of various materials from metals to plastics. These tensile testing systems utilize various technologies to apply the range of tensile forces. Standard tensile forces may be applied with electromechanical tensile tester while higher tension loads require a static hydraulic tensile system.

FURNACE there are three zone resistance wire will be furnaces are of split construction to facilitate fast and easy loading the pre-assembled specimen. The case has constructed from stainless steel with Al and hard insulation board end plates. The optional front cutout allow the use of side-entry high-temperature extensometer. Adjustable stainless steel latches keep the furnace halves locked together during use .but have then easily opened once testing has complete. The furnace has available with optional heavy duty bracket or mountings. which attach to the wide range of testing systems. An extensive range of standard controllers has available to suit most test regimes.

Principle operation The resistance wire has wound on the recrystallized alumina tube in three independent zones form the furnace element. This three-zone format allows the user to tailor the furnace temperature gradient. creating a uniform central zone. High performance ceramic fiber insulation is used(fire bricks are used) to reduce heat losses and provide fast heating rates. The specimen has heated through the combination of convection and radiation dependent in the test temperature. The furnace bore has been optimized to suit a full range of pullrods and pushrods has available to allow compatible grips to be used within our range of furnaces.

Figure 3.6 furnace

when we are increasing the temperature. That time furnace is remaining closed and inside the furnace three heater will increase the temperature

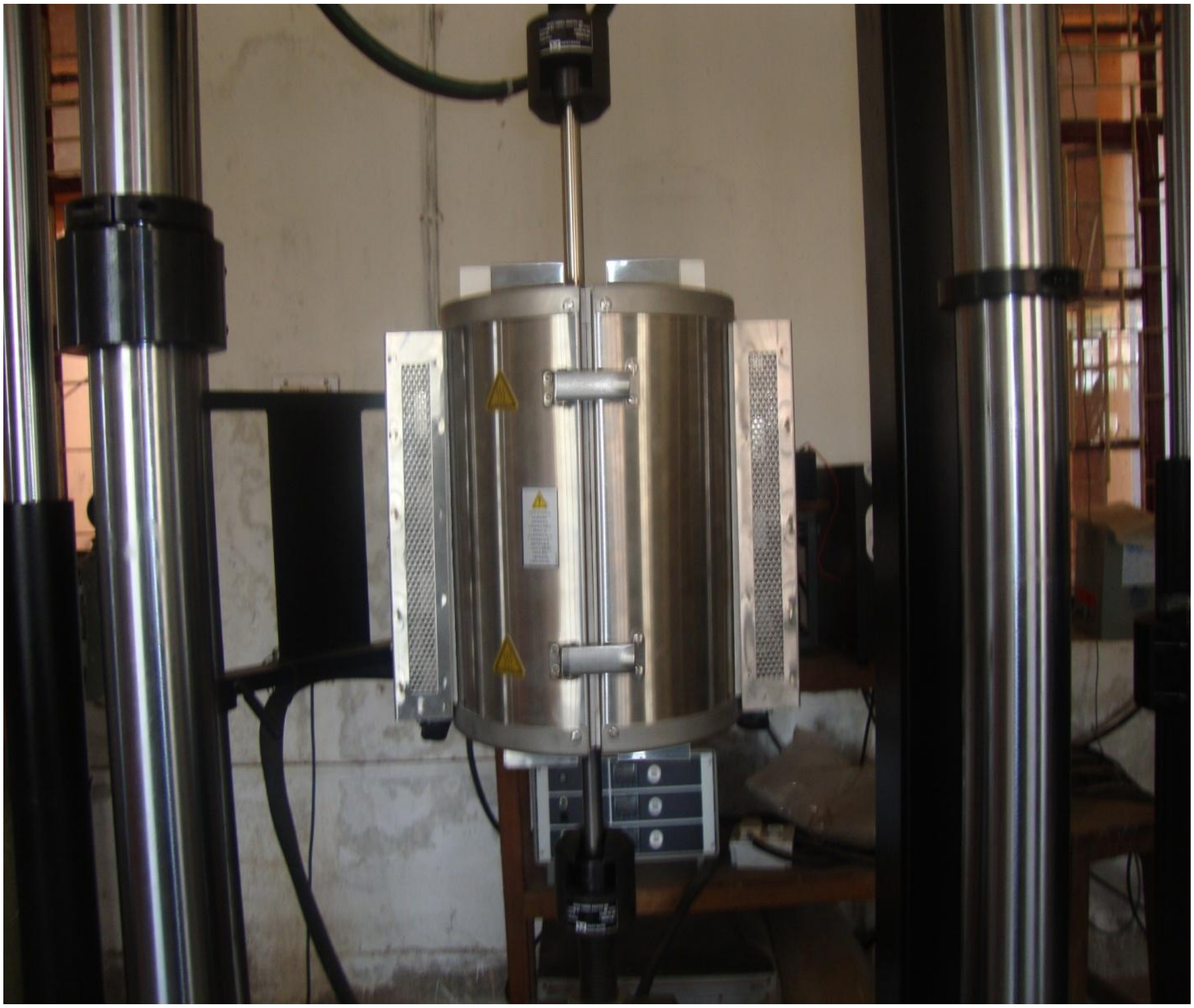


Figure 3.7 Closed furnace

Grips in furnace A range of high-temperature specimen grips and holders is available to suit the pull rods and pushrods required. A variety of grip and holder types has available include the commonly used screw ended style.

Mounting brackets for furnace

Furnaces need to firmly attached the test system during use but also readily moved to allow access to the specimen and load string for setting-up.
A variety of mounting has used depending on the furnace type and design. Roller mount has frequently used for slot-fronted furnaces. Clam-shell designs often use rotating mounts.

Figure 3.8 Hinged Furnace Mounting Bracket

TEMPERATURE CONTROL

Temperature control systems have designed for controlling the heat output of furnaces. chambers and ovens as well as controlling the cooling of chambers when connected to the liquid nitrogen source. The control systems have offered for use with new creep. stress rupture or hot tensile systems, they can be added an existing frame using an existing furnace or chamber .The control system may either be built into the panel that has part of the frame itself or provided in the standalone cabinet to house the controls. electronics and cabling connections. The systems can be configured for use with either a manual. The control systems are compatible with all furnace systems offered as the new equipment. It can be configured to operate nearly any furnace chamber, or oven with any one of several different thermocouple types. Three-zone control systems have designed for heat only furnaces with three separate zones of the heating elements. and typically three different thermocouples to control those zones. Single-zone control systems are designed for heat only furnaces with one zone of heating and one thermocouple. They may also be set up to control both the heating and cooling function for chambers that have both heating elements and the piped.

Figure 3.9 Temperature controller

Pull rod and push rod for furnace

A full range of pull rods and pushrods has available to allow compatible grips to be used within our range of furnaces. Pull rods and pushrods have manufactured from high temperature materials for strength and resistance to corrosion and oxidation. Specimen adaptors and holders of various designs.water-cooled adaptors and other complementary accessories have available

Figure 3.10 Pull rod and pushrod

Threaded-End and Button-End Grip Bodies

The bottom end holder are engineered to the further production floor testing. The hole sleeve design eradicate the require for specimen to the thread in to the holder . this is decreasing the loading time for each specimen. The open face aspect is increase the no difficulty in loading each specimen.the the operator can be view of specimen location throughout the loading process in instron machine.

Principle and operation.

The shoulder end holder mount openly onto the threaded piece of spherically seated tension rod projected to decrease loading time, the shoulder end holder is face open. rip sleeve drawing. After placing the specimen keen on the open rip sleeve, the machinist then places the next rip sleeve above the specimen with brings the external sleeve over the assemblage. the machinist bring the outer sleeve above the specimen and bend it, the mechanism lock the specimen into place. the pre experiment load force has apply to eliminate loose amid of the grip and specimen. The spherically place tension rod would be mechanically make straight the specimen if it has located off center. This characteristic make sure the tension from the casing is apply the entire of the specimen during the period of the experiment.Shoulder end holders have designed to fulfill with ASTM E. and additional global standard.and can be made to customer condition. A large range of achievable button head,shank hole and radius dimension sure compatibility The threaded end holder build up directly onto the threaded section of the spherically place tension rod. The threaded end specimen is after that fixed into every threaded end holder. Once the specimen has situated properly in the two threaded end holders

Application rang

- Type of Loading: static tension
- Specimen Material wide variety of metals. Counting aluminium cast iron and steel .Specimen type machined shoulder end specimen machined thread end specimen.

Figure 3.11 Threaded-End Specimen Holders

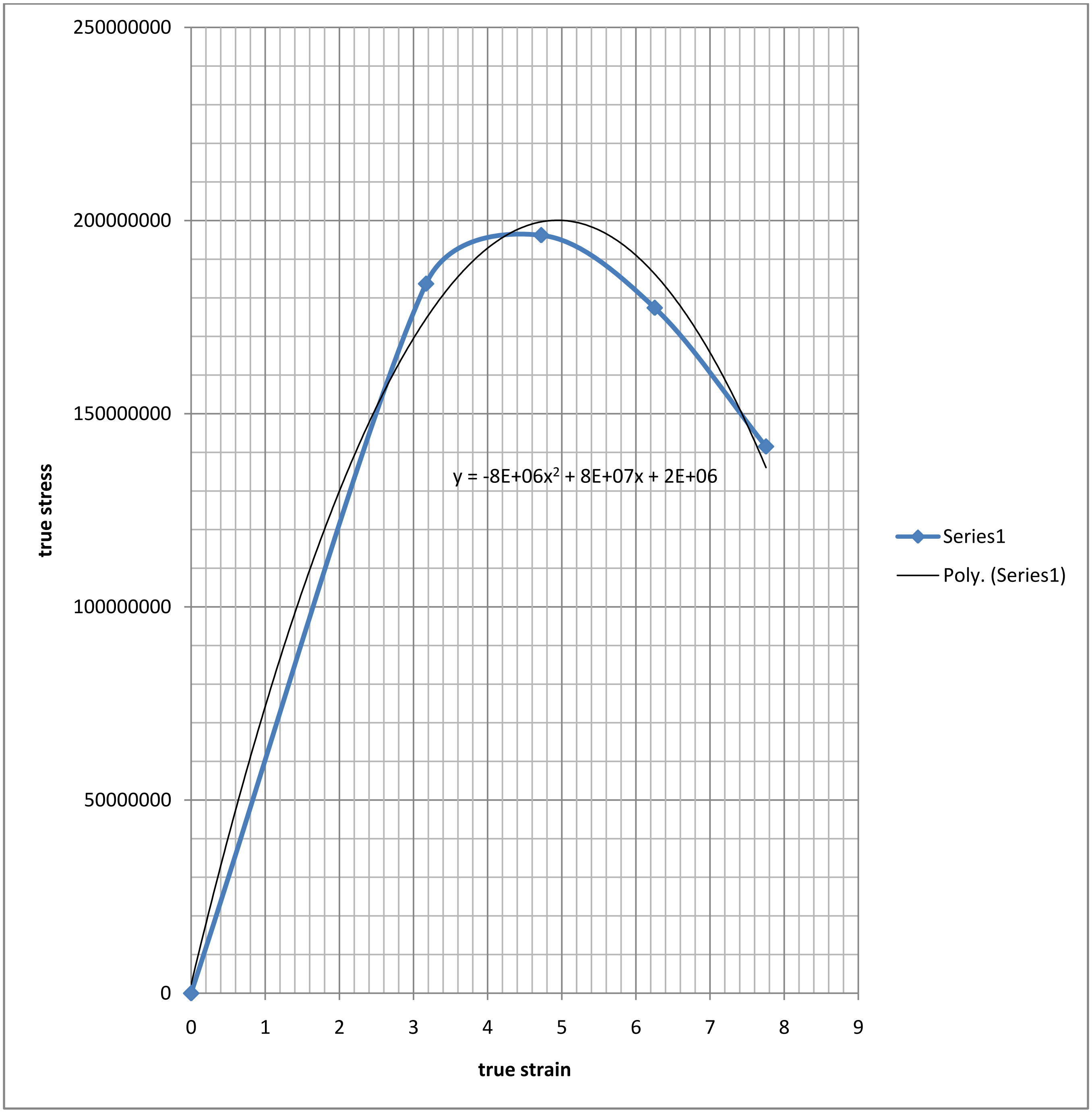
4.) RESULT AND DISCUSSION:

After carrying out the experiment on each aluminium specimen subjected to necking at different range of high temperature. We determined the stress from load that is applied gradually to specimen and strain is determined from change in length of specimen during necking. With the help of stress and strain values obtained in former, we plot the stress versus strain. The tabulation for each specimen and their respective stress strain plots are given below:

1.) Specimen first tabulation : Temperature (37 degree Celsius)

Extension	load N	load KN	Initial length	True strain %	True stress
0	0	0	61.99	0	0
0.003	1.23854	0.001239	61.993	0	0
0.998	5545.036	5.545036	62.988	3.169022	1.84E+08
1.999	5832.119	5.832119	63.989	4.722806	1.96E+08
3.001	5191.903	5.191903	64.991	6.254332	1.77E+08
4.003999	4078.458	4.078458	65.994	7.755293	1.42E+08

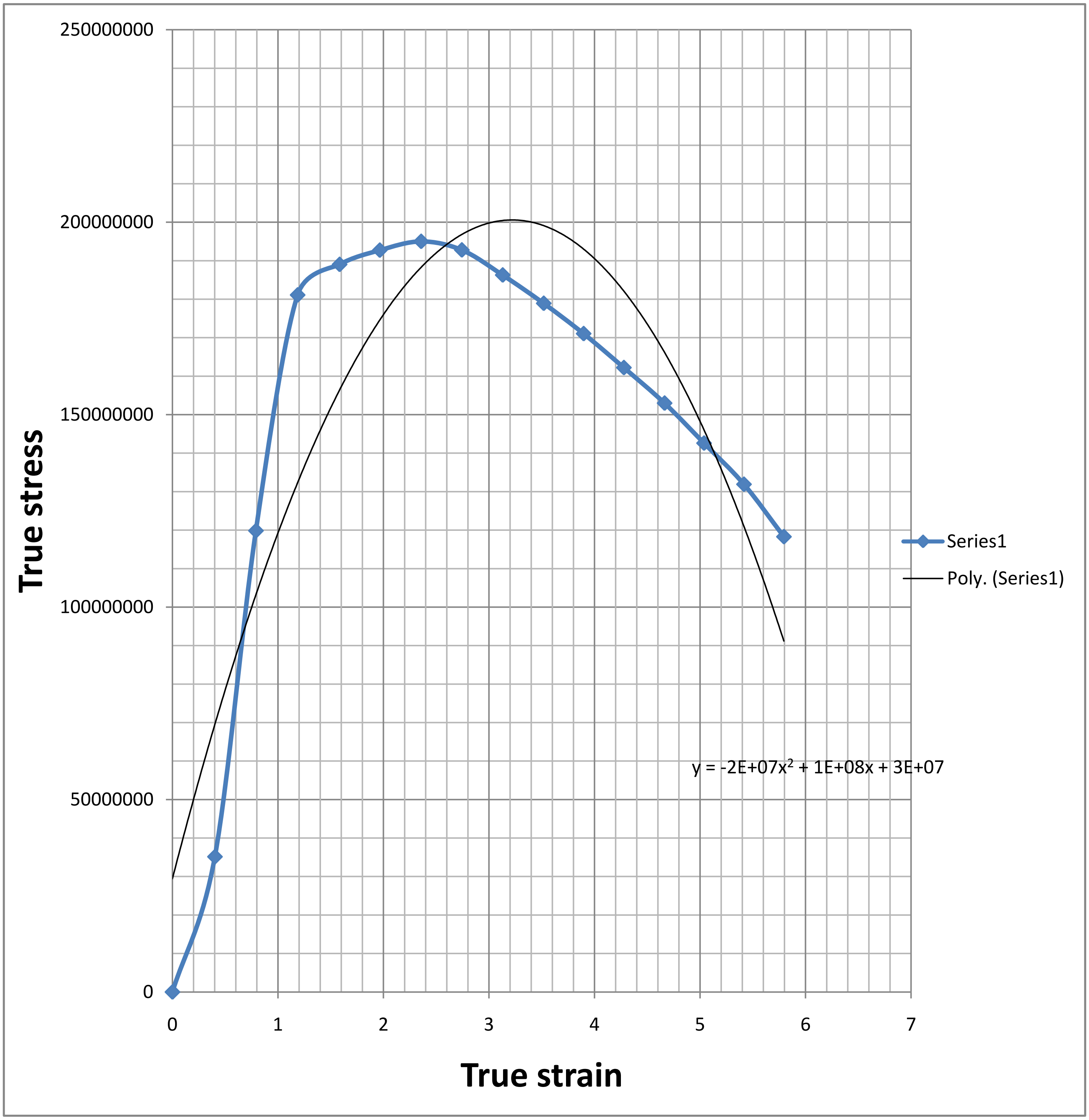
Graph between the true strain and stress true strain is the X direction . and the true stress is the Y direction



2).Specimen second tabulation: Temperature (90 degree Celsius)

Extension mm	Load N	load KN	int length	True strain %	True stress Pa
0	0	0	62.94	0	0
0.253	1033.122	1.033122	63.193	0.402734	3.51E+07
0.499	3508.773	3.508773	63.439	0.791243	1.20E+08
0.75	5281.276	5.281276	63.69	1.1861	1.81E+08
1.004	5490.967	5.490967	63.944	1.584095	1.89E+08
1.248	5577.054	5.577054	64.188	1.964934	1.93E+08
1.5	5621.153	5.621153	64.44	2.356744	1.95E+08
1.749	5535.605	5.535605	64.689	2.742388	1.93E+08
2	5328.01	5.32801	64.94	3.129629	1.86E+08
2.253	5097.705	5.097705	65.193	3.518444	1.79E+08
2.5	4855.059	4.855059	65.44	3.896586	1.71E+08
2.75	4586.932	4.586932	65.69	4.27787	1.62E+08
3.004	4309.247	4.309247	65.944	4.663771	1.53E+08
3.251	4001.569	4.001569	66.191	5.037615	1.43E+08
3.502	3687.571	3.687571	66.442	5.416086	1.32E+08
3.754	3294.327	3.294327	66.694	5.79463	1.18E+08
4.001	667.829	0.667829	66.941	6.164278	2.41E+07

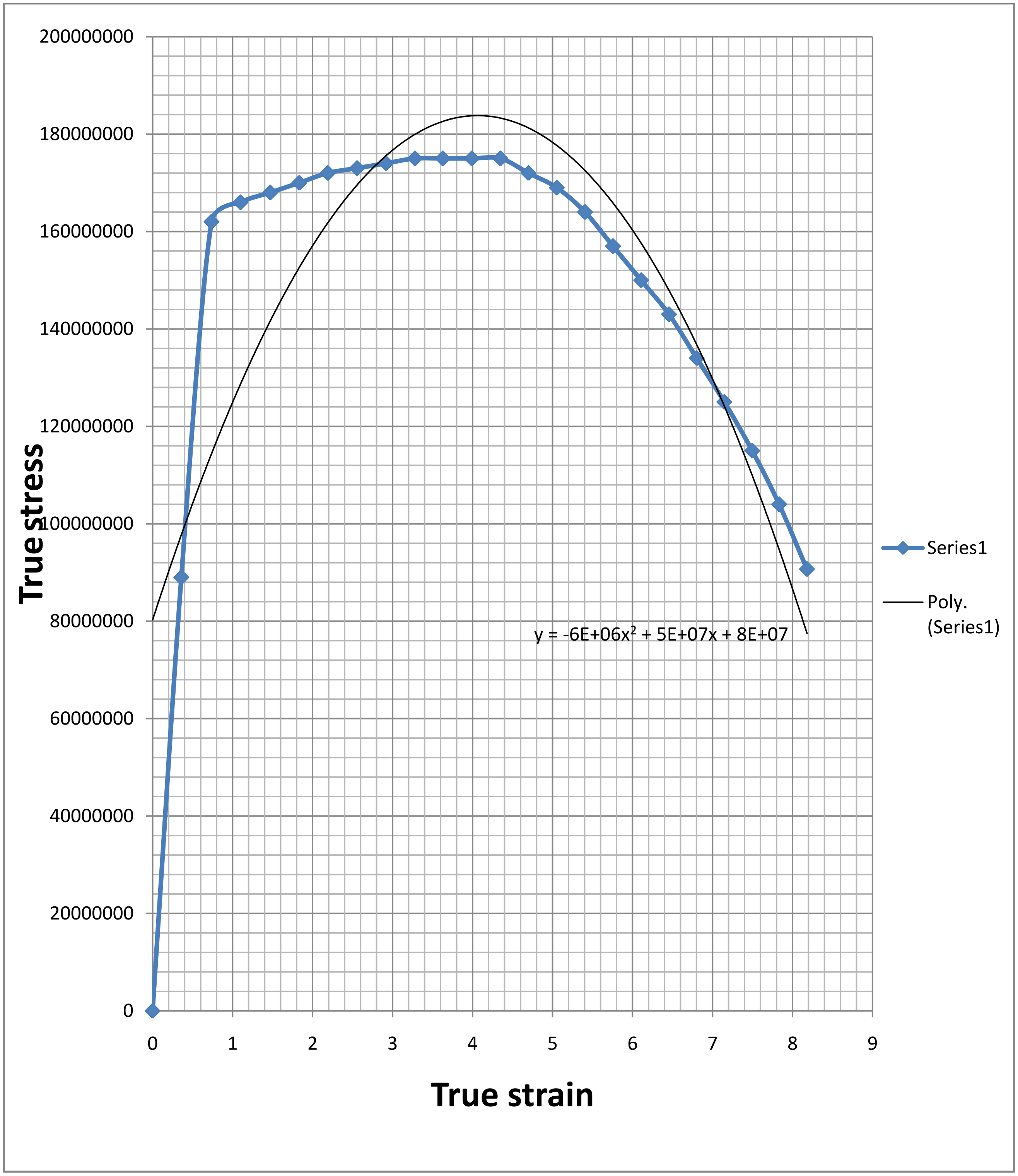
Graph between the tr ue strain and stress



3.) Specimen third tabulation: Temperature (130 degree Celsius)

Extension mm	Load N	load KN	int length	True strain %	True stress Pa
0	0	0	67.46	0	0
0.244	2633.637	2.633637	67.704	0.35954	8.90E+07
0.5	4788.474	4.788474	67.96	0.736921	1.62E+08
0.747	4867.575	4.867575	68.207	1.09969	1.66E+08
1.001	4926.507	4.926507	68.461	1.471372	1.68E+08
1.25	4962.081	4.962081	68.71	1.834402	1.70E+08
1.495	4994.02	4.99402	68.955	2.190318	1.72E+08
1.748	5013.09	5.01309	69.208	2.556531	1.73E+08
1.999	5027.525	5.027525	69.459	2.918529	1.74E+08
2.251	5032.929	5.032929	69.711	3.280655	1.75E+08
2.494	5024.222	5.024222	69.954	3.628612	1.75E+08
2.748	5003.396	5.003396	70.208	3.991029	1.75E+08
2.999	4968.91	4.96891	70.459	4.34788	1.75E+08
3.247	4882.633	4.882633	70.707	4.69922	1.72E+08
3.498	4764.902	4.764902	70.958	5.053558	1.69E+08
3.748	4603.278	4.603278	71.208	5.405239	1.64E+08
3.997999	4414	4.414	71.458	5.755688	1.57E+08
4.25	4201.81	4.20181	71.71	6.107704	1.50E+08
4.499999	3973.263	3.973263	71.96	6.455704	1.43E+08
4.749999	3725.033	3.725033	72.21	6.802498	1.34E+08
5	3449.26	3.44926	72.46	7.148094	1.25E+08
5.253	3161.705	3.161705	72.713	7.496624	1.15E+08
5.498	2843.065	2.843065	72.958	7.832981	1.04E+08
5.751999	2483.681	2.483681	73.212	8.180502	9.07E+07
5.996999	1337.192	1.337192	73.457	8.51457	4.90E+07
6.127999	14.72922	0.014729	73.588	8.692737	540868.6

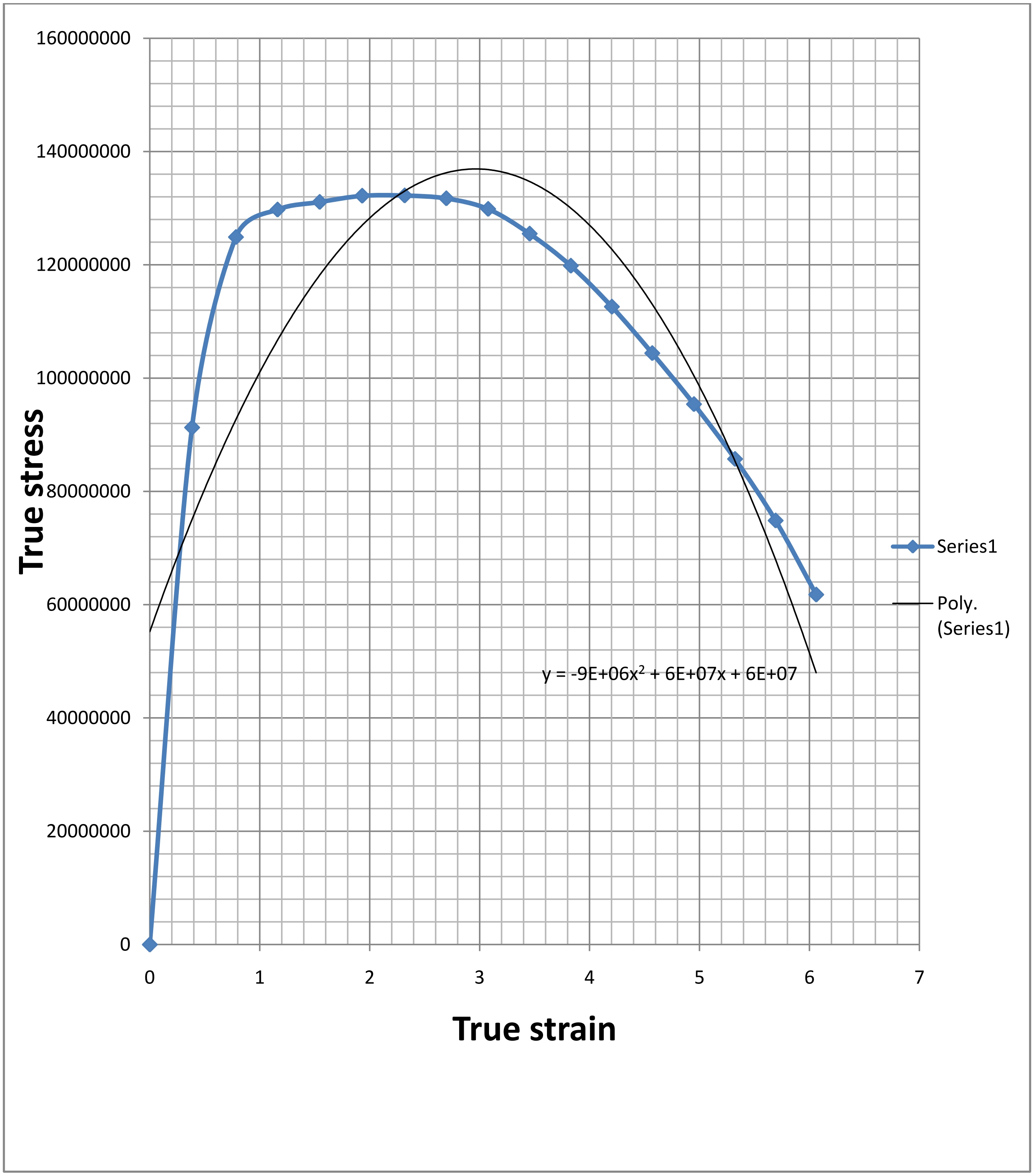
Graph between the true strain and stress true strain is the X direction . and the true stress is the Y direction



4.) Specimen four tabulation: Temperature (170 degree Celsius)

Extension mm	Load N	load kn	int length	True strain %	True stress Pa
0	0	0	64.1	0	0
0.245	2486.189	2.486189	64.345	0.384625	9.13E+07
0.502	3388.081	3.388081	64.602	0.783257	1.25E+08
0.747	3506.431	3.506431	64.847	1.161803	1.30E+08
0.996	3529.277	3.529277	65.096	1.545066	1.31E+08
1.248	3545.019	3.545019	65.348	1.931457	1.32E+08
1.501	3532.604	3.532604	65.601	2.317885	1.32E+08
1.75	3505.787	3.505787	65.85	2.696751	1.32E+08
2.001	3442.851	3.442851	66.101	3.077213	1.30E+08
2.251	3314.604	3.314604	66.351	3.454726	1.25E+08
2.5	3153.317	3.153317	66.6	3.829317	1.20E+08
2.749	2951.958	2.951958	66.849	4.202511	1.13E+08
2.995	2726.907	2.726907	67.095	4.569845	1.04E+08
3.25	2482.303	2.482303	67.35	4.949199	9.54E+07
3.502	2222.232	2.222232	67.602	5.322683	8.57E+07
3.752	1933.317	1.933317	67.852	5.691829	7.49E+07
4.003	1589.789	1.589789	68.103	6.061085	6.18E+07
4.204999	181.4892	0.181489	68.305	6.357268	7074016

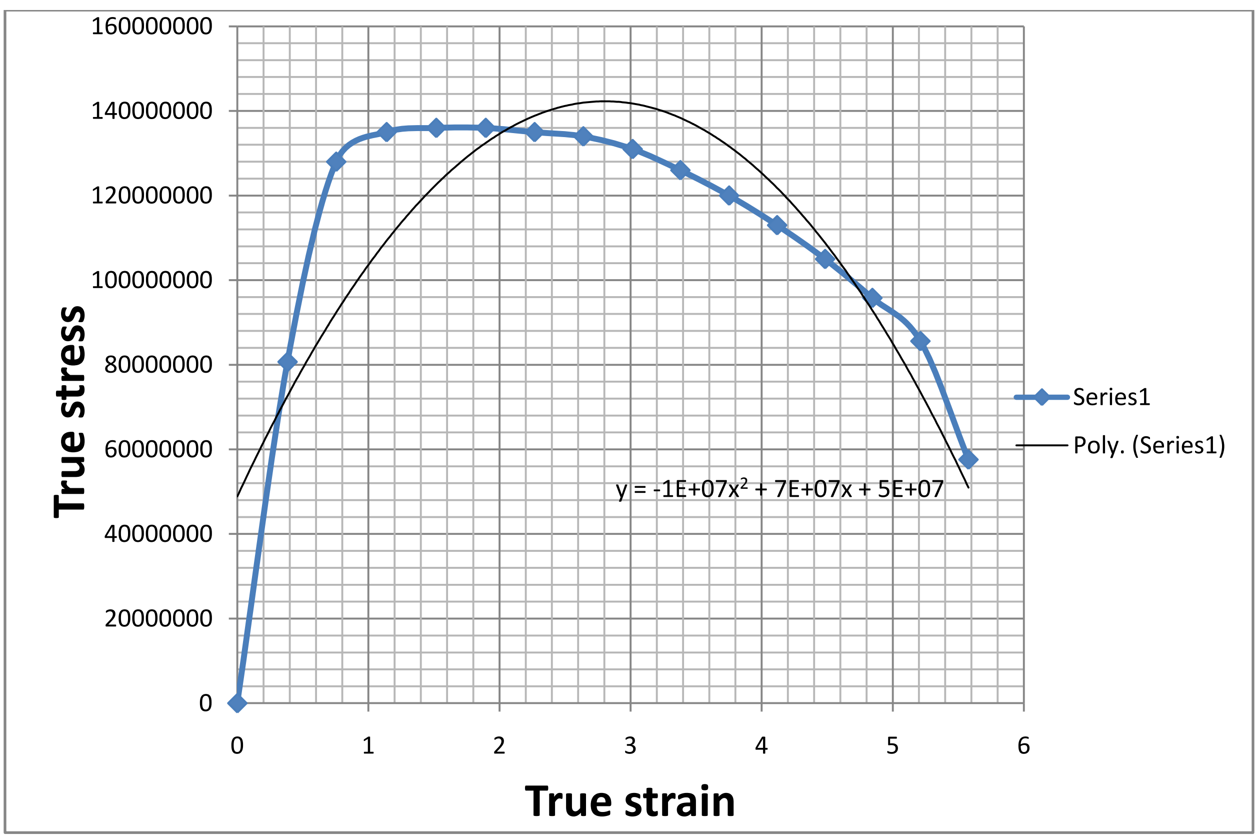
Graph between the true strain and stress true strain is the X direction . and the true stress is the Y direction



5.) Specimen five tabulation : Temperature (210 degree Celsius)

Extension mm	Load N	load KN	int length	True strain %	True stress Pa
0	0	0	65.39	0	0
0.251	2504.826	2.504826	65.641	0.383128	8.07E+07
0.495	3964.739	3.964739	65.885	0.754169	1.28E+08
0.749	4146.134	4.146134	66.139	1.138959	1.35E+08
1	4162.439	4.162439	66.39	1.517756	1.36E+08
1.251	4158.571	4.158571	66.641	1.895123	1.36E+08
1.5	4121.751	4.121751	66.89	2.268082	1.35E+08
1.749	4069.23	4.06923	67.139	2.639655	1.34E+08
2.002	3968.168	3.968168	67.392	3.015788	1.31E+08
2.248	3808.193	3.808193	67.638	3.380162	1.26E+08
2.5	3611.791	3.611791	67.89	3.752053	1.20E+08
2.749	3380.473	3.380473	68.139	4.118163	1.13E+08
2.999	3127.86	3.12786	68.389	4.484399	1.05E+08
3.246	2846.373	2.846373	68.636	4.844928	9.58E+07
3.498	2533.045	2.533045	68.888	5.211421	8.56E+07
3.751	1699.124	1.699124	69.141	5.578021	5.76E+07
3.937	45.20081	0.045201	69.327	5.846683	1537330

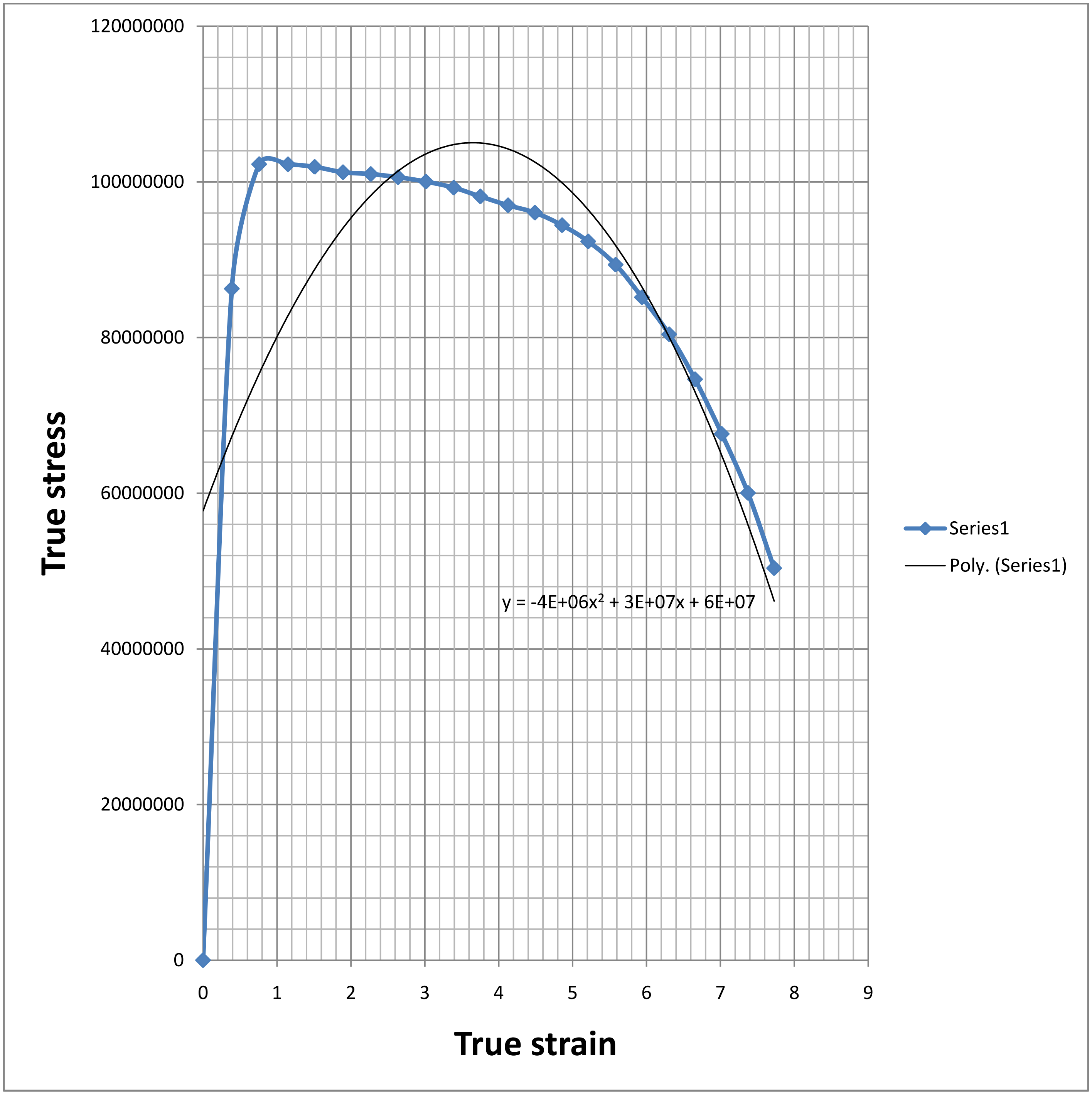
Graph between the true strain and stress true strain is the X direction . and the true stress is the Y direction



6.) Specimen six tabulation : Temperature (250 degree Celsius)

Extension mm	Load N	load KN	int length	True strain %	True stress Pa
0	0	0	65.39	0	0
0.252	2495.264	2.495264	65.642	0.389233	8.63E+07
0.495	2946.896	2.946896	65.885	0.758745	1.02E+08
0.753	2934.929	2.934929	66.143	1.149578	1.02E+08
0.992	2915.086	2.915086	66.382	1.51027	1.02E+08
1.247	2884.229	2.884229	66.637	1.89368	1.01E+08
1.498	2866.886	2.866886	66.888	2.269646	1.01E+08
1.746	2844.654	2.844654	67.136	2.639734	1.01E+08
1.999	2818.132	2.818132	67.389	3.015879	1.00E+08
2.253	2785.808	2.785808	67.643	3.392092	9.93E+07
2.497	2744.155	2.744155	67.887	3.752166	9.81E+07
2.752	2702.192	2.702192	68.142	4.127091	9.70E+07
3	2666.203	2.666203	68.39	4.490382	9.61E+07
3.252	2611.75	2.61175	68.642	4.858185	9.44E+07
3.495	2545.23	2.54523	68.885	5.211575	9.24E+07
3.751	2453.634	2.453634	69.141	5.582526	8.94E+07
3.997999	2330.323	2.330323	69.388	5.939135	8.52E+07
4.254	2192.099	2.192099	69.644	6.307402	8.04E+07
4.498	2027.557	2.027557	69.888	6.657148	7.46E+07
4.750999	1830.239	1.830239	70.141	7.018507	6.76E+07
5	1619.293	1.619293	70.39	7.372883	6.00E+07
5.25	1353.767	1.353767	70.64	7.727422	5.04E+07
5.493999	420.3412	0.420341	70.884	8.072245	1.57E+07

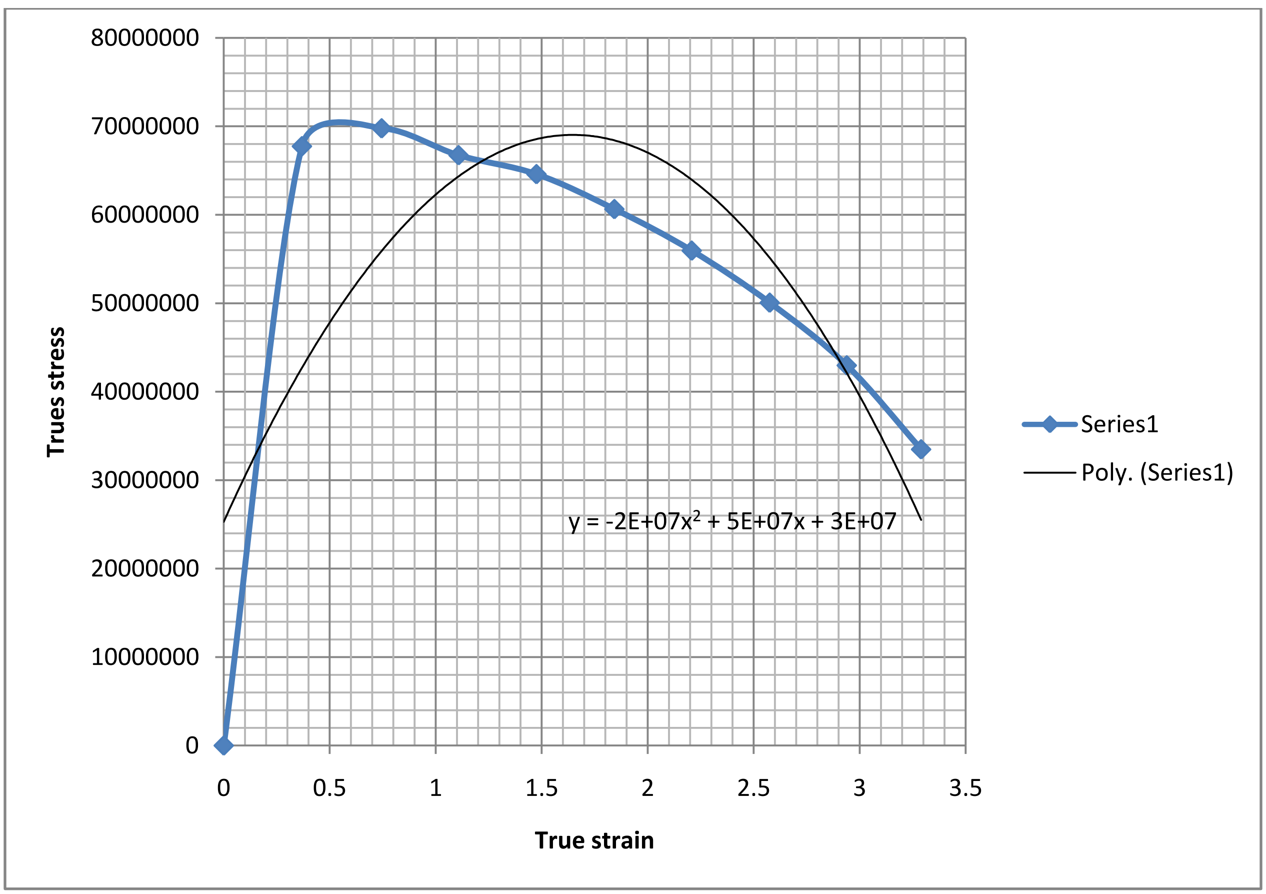
Graph between the true strain and stress true strain is the X direction . and the true stress is the Y direction



7.) Specimen seven tabulation : Temperature (290 degree Celsius)

Extension mm	Load N	load KN	int length	True strain %	True stress Pa
0	0	0	67.15	0	0
0.247	1908.3	1.9083	67.397	0.368631	6.77E+07
0.501	1958.054	1.958054	67.651	0.744777	6.98E+07
0.747	1865.917	1.865917	67.897	1.107733	6.67E+07
0.997	1799.425	1.799425	68.147	1.475245	6.46E+07
1.248	1683.159	1.683159	68.398	1.842874	6.06E+07
1.498	1547.214	1.547214	68.648	2.207699	5.59E+07
1.751	1379.504	1.379504	68.901	2.575552	5.01E+07
2.002	1179.897	1.179897	69.152	2.939165	4.30E+07
2.245	916.0483	0.916048	69.395	3.289934	3.35E+07
2.367	375.5571	0.375557	69.517	3.465577	1.38E+07

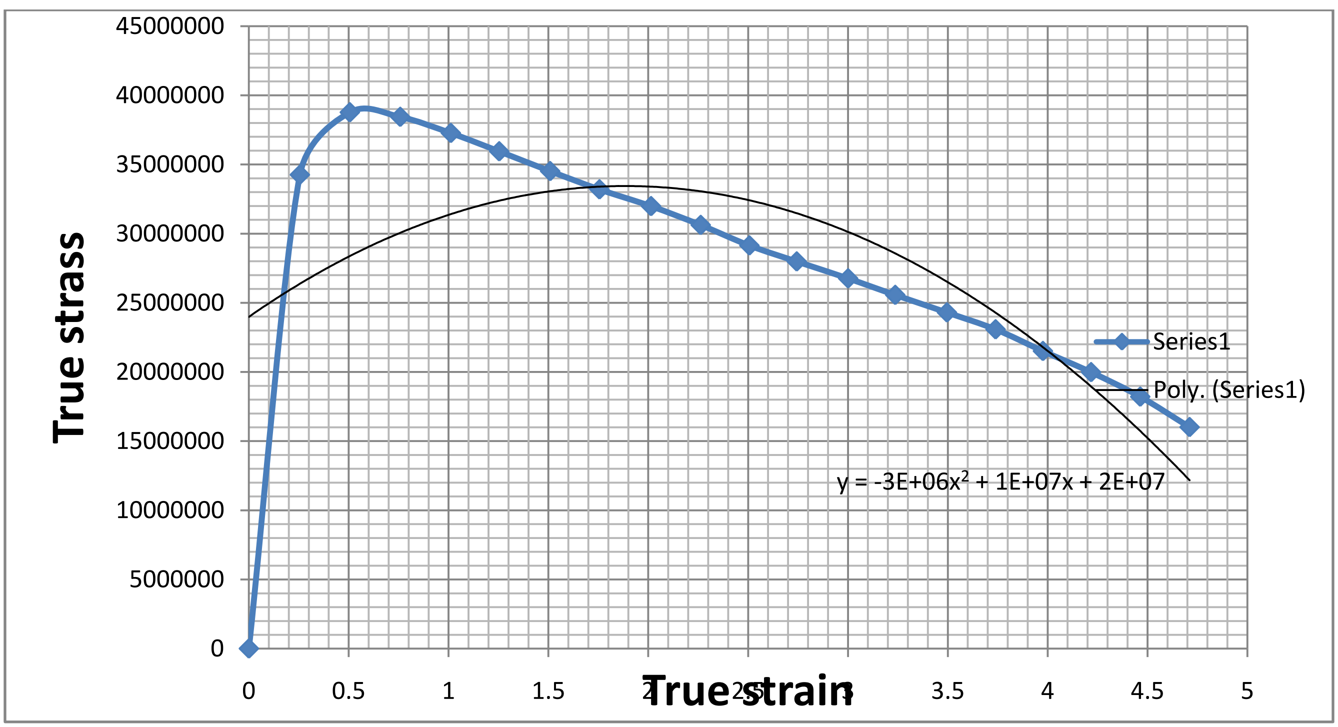
Graph between the true strain and stress true strain is the X direction . and the true stress is the Y direction



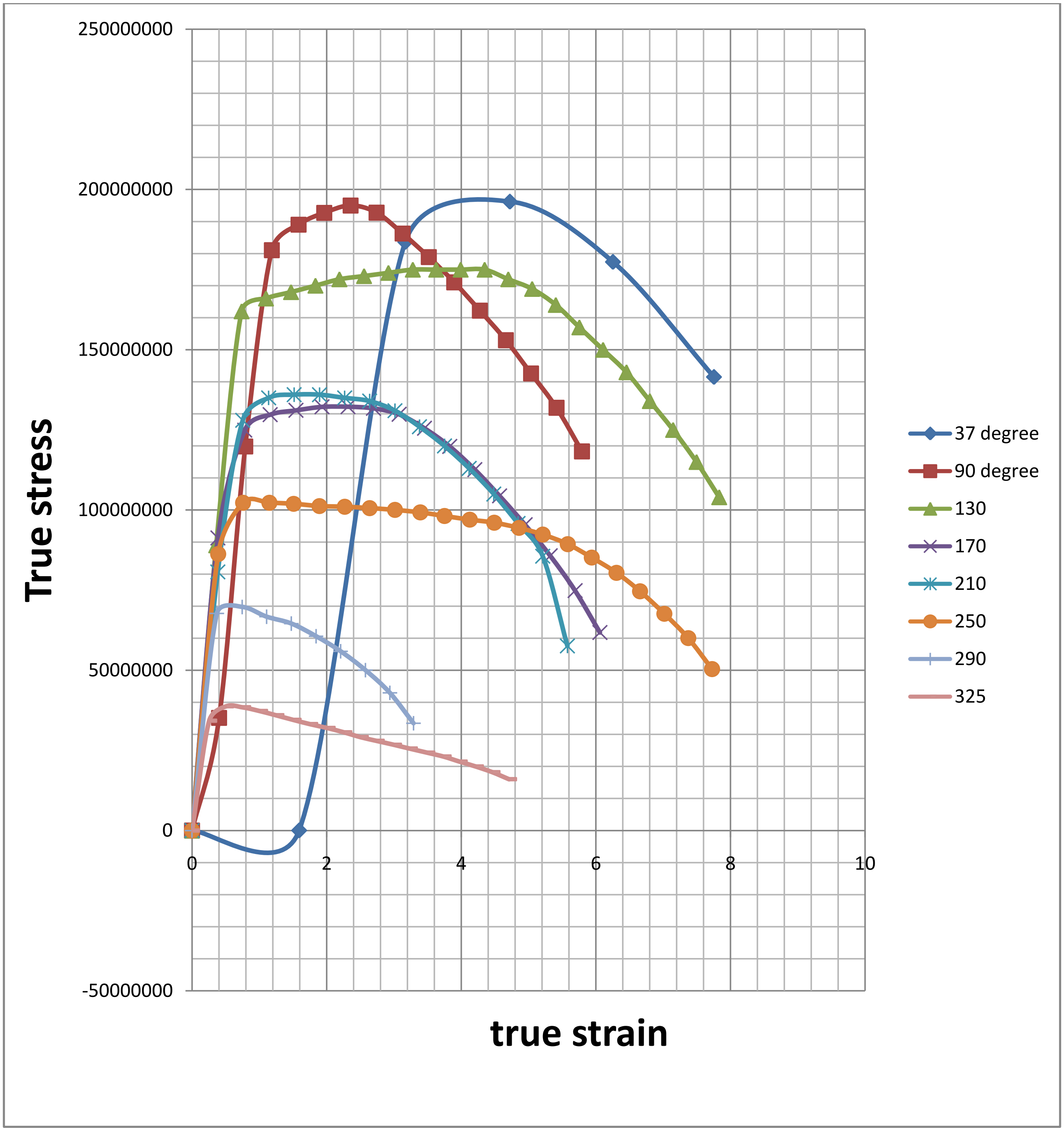
8.) Specimen eight tabulation : Temperature (325 degree Celsius)

Extension mm	Load N	load KN	int length	True strain %	True stress Pa
0	0	0	65.72	0	0
0.172	1119.835	1.119835	65.892	0.255304	3.43E+07
0.337	1264.189	1.264189	66.057	0.505416	3.88E+07
0.504	1250.289	1.250289	66.224	0.757924	3.84E+07
0.672	1209.257	1.209257	66.392	1.011302	3.73E+07
0.833	1163.495	1.163495	66.553	1.253522	3.59E+07
1.003	1114.289	1.114289	66.723	1.508647	3.45E+07
1.168	1069.054	1.069054	66.888	1.755648	3.32E+07
1.341	1027.345	1.027345	67.061	2.013971	3.20E+07
1.508	981.1807	0.981181	67.228	2.262703	3.06E+07
1.672	931.4456	0.931446	67.392	2.506366	2.91E+07
1.832	892.3616	0.892362	67.552	2.743516	2.80E+07
2.006	851.1763	0.851176	67.726	3.00078	2.68E+07
2.166	811.171	0.811171	67.886	3.236761	2.56E+07
2.342	769.0232	0.769023	68.062	3.495698	2.43E+07
2.508	728.5584	0.728558	68.228	3.739311	2.31E+07
2.67	677.4364	0.677436	68.39	3.976482	2.15E+07
2.835	627.8082	0.627808	68.555	4.21747	2.00E+07
3.004	570.7148	0.570715	68.724	4.463698	1.82E+07
3.174	500.5116	0.500512	68.894	4.710773	1.60E+07
3.196	485.4202	0.48542	68.916	4.742703	1.55E+07

Graph between the true strain and stress true strain is the X direction . and the true stress is the Y direction



After the graph is plotted between the true stress strain for each specimen. now we are plotting the combined graph for all 8 specimens. This graph is between true stress and strain . this graph is shown for different temperature of each specimen. The temperature is 37,90,130,170,210,250,290,325 degree Celsius



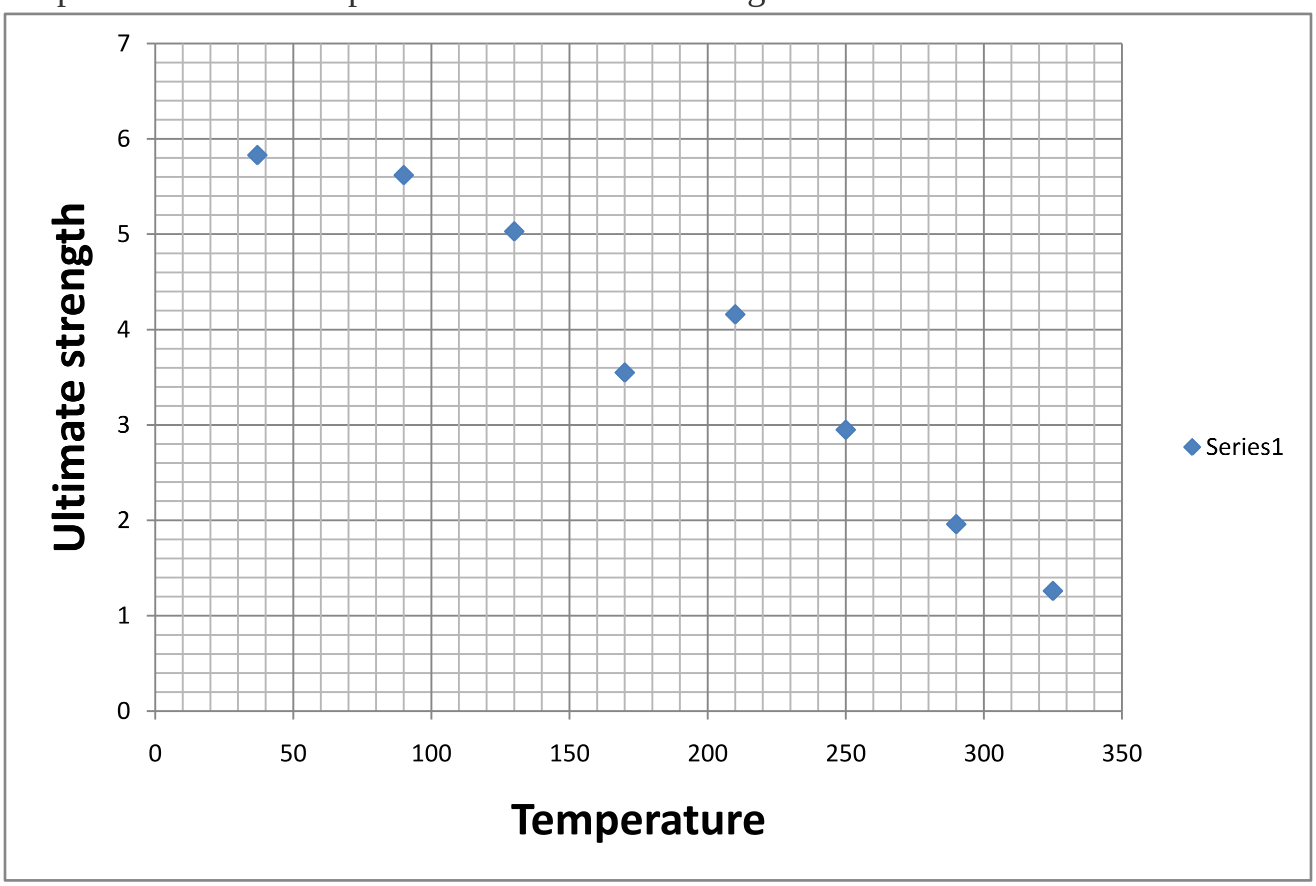
ULTIMATE STRENGTH

Now we are find out the ultimate tensile strength (UTS) for each specimen . then we are plotted the graph between the different range of temperature and ultimate tensile strength. The value of ultimate strength is given below

TABULATION

Temperature	Ultimate Strength
37	5.83
90	5.62
130	5.03
170	3.55
210	4.16
250	2.95
290	1.96
325	1.26

Graph between the temperature and ultimate strength



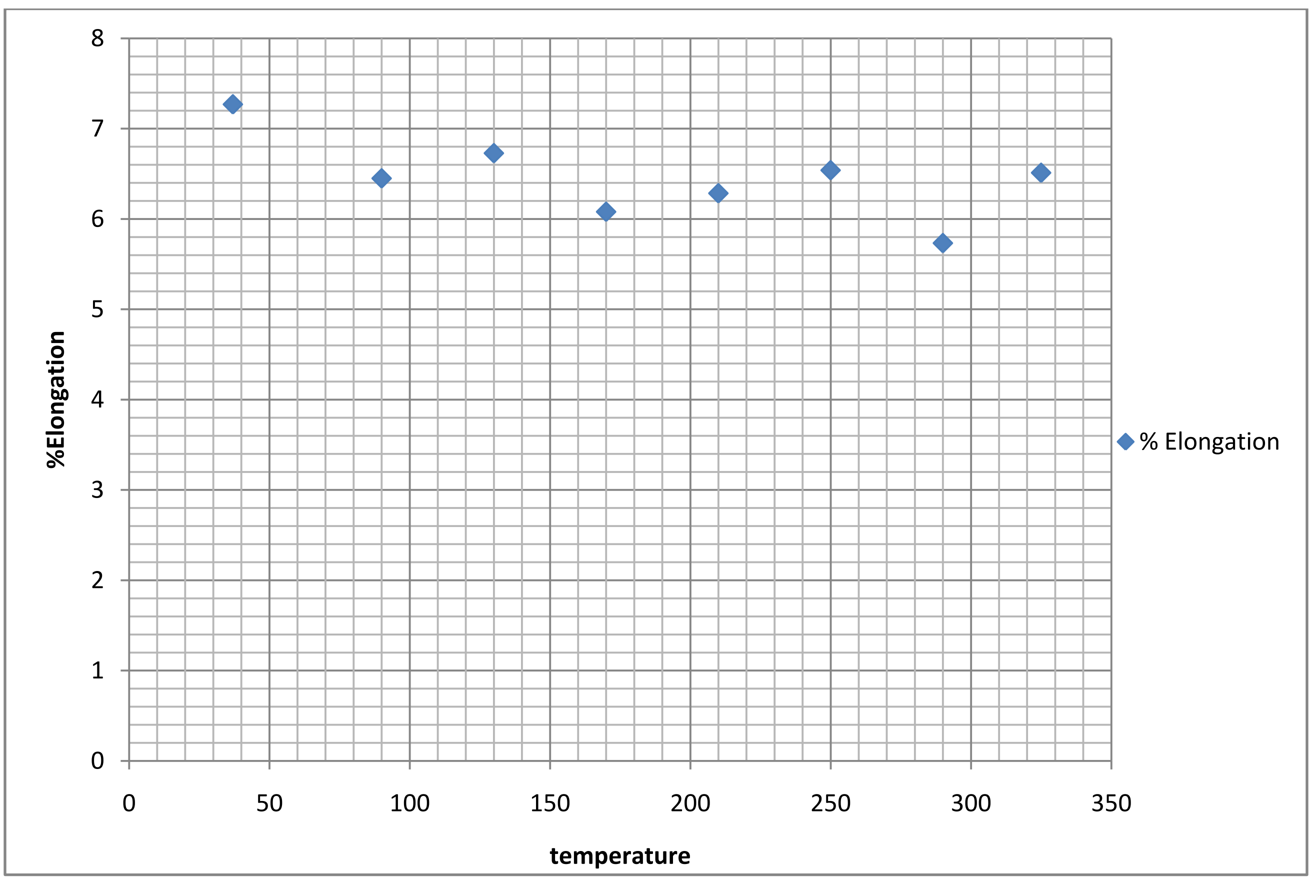
ELONGATION

We are plotted the graph between the temperature and elongation . the tabulation is shown below.

Tabulation

Temperature	% Elongation
37	7.27
90	6.45
130	6.729
170	6.08
210	6.285
250	6.54
290	5.733
325	6.512

The graph is shown



POLINOMIAL EQUATION

The polynomial equation is found out off each specimen of different temperature . When the polynomial equation find out then we are representing these equation in standard form($Y=Ax^2+Bx+c$). then we have determine the value of A , B and C . After find out the value of A, B and C we can plotted the graph between the temperature and A, B and C .

Standard form of polynomial equation $Y=Ax^2+Bx+C$

1.) $\sigma=- 8E+06\epsilon^2+8E+07\epsilon+2E+06$

2.) $\sigma=-2E+07\epsilon^2+1E+08\epsilon+3E+07$

3.) $\sigma=-6E+06\epsilon^2+5E+07\epsilon+8E+07$

4.) $\sigma= -9E+06\epsilon^2+6E+07\epsilon+6E+07$

5.) $\sigma= -1E+07\epsilon^2+7E+07\epsilon+5E+07$

6.) $\sigma= -4E+06\epsilon^2+3E+07\epsilon+6E+07$

7.) $\sigma= -2E+07\epsilon^2+5E+07\epsilon+3E+07$

8.) $\sigma= -3E+06\epsilon^2+1E+07\epsilon+2E+07$

The graph is plotted between the temperature and A, B and C

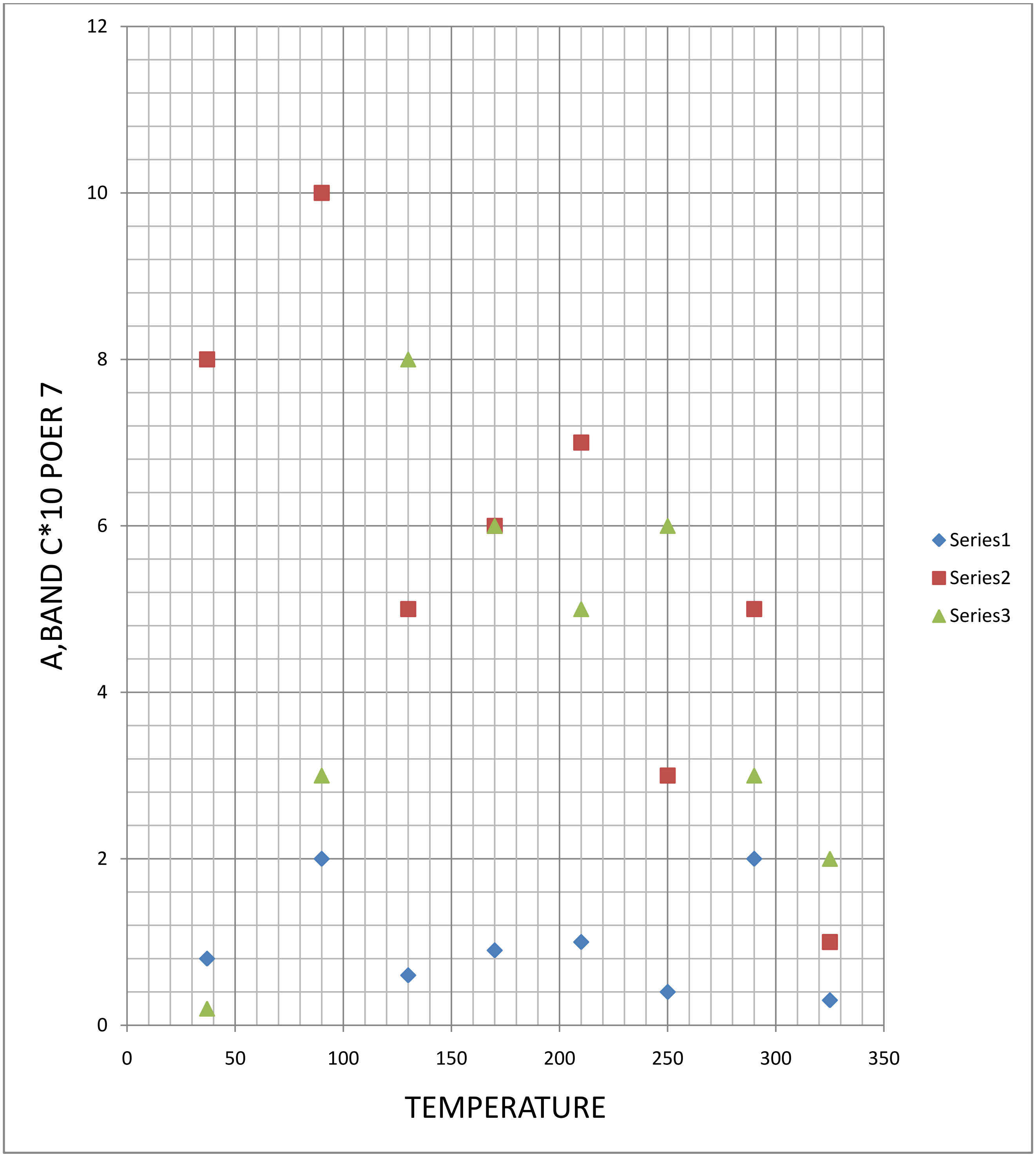
temperature	A	B	C
37	- 0.8E+07	8E+07	0.2E+07
90	-2E+07	10E+07	3E+07
130	-0.6E+07	5E+07	8E+07
170	-0.9E+07	6E+07	6E+07
210	-1E+07	7E+07	5E+07
250	- 0.4E+07	3E+07	6E+07
290	-2E+07	5E+07	3E+07
325	-0.3E+07	1E+07	2E+07

Tabulatin of A,B and C

The value off A is given belo and multiply of 10^7 such that B value is following . and also value of C .

temp.	A	B	C
37	0.8	8	0.2
90	2	10	3
130	0.6	5	8
170	0.9	6	6
210	1	7	5
250	0.4	3	6
290	2	5	3
325	0.3	1	2

The graph is plotted between the A,B,C and the temperature . the series 1 is coefficient of x^2 and B is coefficient of x and C is coefficient of x^0.



Polynomial equation with temperature

We have find out 8 polynomial equation for each specimen. Now we are assume the basic equation polynomial is room temperature (40 degre)specimen . we can derive that equation form of temperature . and find out the each specimen equation for different temperature . the temperature is first one is ROOM TEMPERAURE 37,90,130,170,210,250,290,325,degree Celsius

The basic equation :

$$\sigma= -8*10^{6}\epsilon^{2}*p^{(T-40)}+8*10^{7}\epsilon*q^{(T-40)}+2*10^{6}*r^{(T-40)}$$

equation no. 1

$$\sigma=- 8E+06\epsilon^{2} *p^{(T-40)} +8E+07\epsilon*q^{(T-40)} +2E+06*r^{(T-40)}$$

equation no. 2.

The above both equation are same .

Now the find out the value of p, q and r for each specimen. The temperature range of 90,130,170,210,250,290,325 degree Celsius .

We have put the value of temperature in the equation and find out the next specimen polynomial equation. The value of p, q and r we are assume the value of these parameter p, q and r . the value of p like 1,1.1,1.2,1.5,1.3,1.6,1.4 etc . and

	Specim.2	Specim.3	Spec.4	Spec.5	Spec.6	Spec.7	Spec.8
Temper. Degree Celsius	90	130	170	210	250	290	325
p	1.1	1.4	1.35	1.25	1.5	1.45	1.3
q	1.02	1.05	1.25	1.3	1.4	1.09	1.08
r	1.5	1.6	1.8	1.5	1.9	1.7	1.9

After put the value of different temperature we found the polynomial equation. This equation like the original equation but not the same. The difference is not so much between the orgianl equation value A,B and C and this equation value A1, B1and C1.

5.) Conclusion:

1) The characteristic commercially available aluminium at different high temperature is tested to determine its suitability to be used at elevated temperature.
2) It is seen that as the temperature increases the ultimate tensile strength decreases but the ductility increases.
3) A polynomial equations in the form a

   $$\sigma = A\epsilon^{2} * p^{(T-40)} + B\epsilon * q^{(T-40)} + C * r^{(T-40)}$$

   Is prepared to predict the behaviour of aluminium at different high temperature (room temperature to 325 degree Celsius)

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